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Tomography of 2D Velocity-space Distributions from Combined Synthetic Fast-ion Diagnostics at ASDEX Upgrade

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Collective Thomson scattering (CTS) and fast-ion D_α (FIDA) diagnostics measure 1D functions of the 2D fast-ion velocity distribution functions in magnetically confined plasmas. A single such 1D measurement is usually not sufficient to build accurate tomographies of 2D anisotropic fast-ion velocity distribution functions. But we can compute tomographies from several simultaneous 1D CTS and FIDA measurements. Such reconstructions contain salient features of the underlying 2D fast-ion velocity distribution functions as was shown theoretically in 2004 for two and three synthetic 1D CTS measurements. Since then FIDA measurements have been demonstrated, and several tokamaks have been equipped with multiple FIDA views. In 2012, a second CTS receiver and a second FIDA optical head have been installed on ASDEX Upgrade, so that four simultaneous 1D measurements of the 2D fast-ion distribution function are now possible if CTS and FIDA measurements are used together. We reconstruct 2D fast-ion velocity distribution functions from TRANSP/NUBEAM using combined synthetic 1D CTS and FIDA measurements. Here we develop a new reconstruction prescription that makes use of the recent idea of weight functions. In the past, reconstruction algorithms were made tractable by expansion of the 1D (synthetic) measurements as well as the 2D fast-ion velocity distribution functions into orthonormal sets of base functions. Exploiting CTS or FIDA weight functions we are lead to a simpler reconstruction prescription that is inherently tractable and obviates the use of such expansions. Our prescription is analogue to a tomography but in velocity space rather than in configuration space. Computed tomography in configuration space is widely used in medical imaging (X-ray, PET, MRI scanners) and also in nuclear fusion research. With our prescription we can build tomographies of the 2D velocity distribution function for any set of 1D fast-ion measurements obtained for any machine with multiple CTS or FIDA views or a mix of these. Applying our prescription to a set of real 1D fast-ion measurements will yield an entirely experimentally determined 2D fast-ion velocity distribution function that can be compared with simulations.